A Virtual Observatory of Planetary Surfaces. S. Maurice[1], C. Angleraud[2], L. d'Uston[1], F. Aumonier[2], S. Chevrel[1], Y. Daydou[1], T. Levoir[3], [1]Observatoire Midi-Pyrénées (14 av. Ed. Belin, 31400 Toulouse, France; maurice@obs-mip.fr), [2]GeoTexel SA (Le Causse, 81100 Castres, France ; c.angleraud@geotexel.com), CNES [3](18 Av. Ed. Belin, 31400 Toulouse, France ; thierry.levoir@cnes.fr).

Observation of Planetary Surfaces: Study of the origin, composition and alteration of planetary regoliths and soils is a key to set constraints on the formation and evolution of telluric planets. Surfaces are indeed complex interfaces that integrate over time the planet history and its interactions with the rest of the Solar System. Progresses derive from various disciplines: internal structure, gravity field, plasma physics, atmosphere and climatology, orbital history, etc.

Scientific spacecraft that explore the planets Moon, Venus, Mars, Mercury, as well as icy satellites of the outer giants, send back at present time (as they have done during the last 40 years, with more moderate telemetry rates) gigabytes of remote sensing data every day. Many of these data are images (raster files) of planetary surfaces, which must be read, projected, compared, etc, by scientists.

The virtual observatory we propose aims at navigating freely in a multi-dimensional space of existing images of different origins.

Planetary Mapping Rationale: Data from remote sensing instruments have been preciously archived and stored on servers by various organisms. Depending on the practices when data were collected, on the existing state of the art technologies then available, these vast databases are far from being standardized. Although many efforts have been made to unify formats, images of the same target may still be available in many flavors, geometry and inevitably resolution.

Consequently, although no problem arise from sharing these publicly-available data among scientists, the (even small) differences between the datasets cause large waste of time in writing utilities or software tricks to compare or combine different data sets to validate or reject scientific hypothesis. As an example, what time consuming it can be for a scientist to switch from a sinusoidal projection to an orthographic one! Or to compare spectral reflectance images at a few 100's m resolution with gamma-ray composition maps at several 10's km resolution…

A project called SPINS (Server - Planets - Imagery - Navigation - Services) is under development in France to facilitate the work of scientists regarding mapping issues on a planet, to allow the simultaneous study of various data sets.

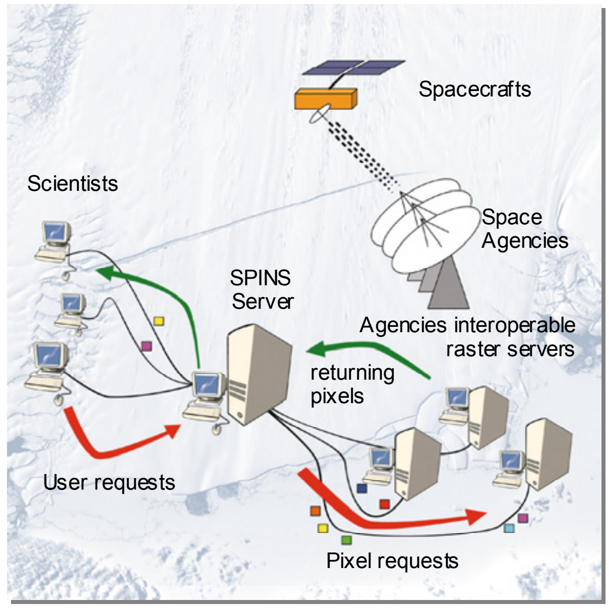

Figure 1: Client-Server schematics

Virtual Observatory: The SPINS project consists of a distributed image server fed by existing data sources, which provides on-the-fly assembly and geometric transforms in order to access a truly seamless planetary image database for all spherical or near spherical bodies of the Solar System. Beyond providing access, SPINS will also supply direct viewing and navigation in real-time through the images without requiring prior download.

The SPINS project is built on the top of GeoTexel's real-time technology. It provides several key features:

1/ Raster data are stored using a wavelet technique (soon JPEG2000). This allows both compression and progressive transfer from the server to the end-user. Compression is reversible to preserve measurements integrity. Progressive transfer results from the localization of the wavelet transform which allows the delivery of the image in packets, sub-sectioned by resolution and area of interest. From this choice, the bandwidth and server's load are greatly reduced.

2/ On top of using wavelet transform for data storage, a cache (both RAM and disk) mechanism is provided reducing again the required bandwidth. Locally stored data are transferred once and can be made persistent across sessions spanning over several days. It also allows navigation off-line. Synchronization is fully automated.

3/ Pieces of raster images, once available on the client's computer, are decompressed (only for the area being visualized) then geometrically transformed as well as re-sampled, and finally, assembled.

4/ Along with the imagery itself, XML descriptive metadata are also sent to the user for him/her to correctly interpret what is seen. XML use is based on DIMAP (for Digital Image MAP, a public industry standard developed by CNES and Spot Image). At extraction time (see 6), metadata from the different images are agglomerated in order to guarantee traceability of data. Each image is documented using XML metadata

5/ Selection of appropriate images among all available ones for an area of interest is automated by an expert system which weights each potential image against a user profile. Then most interesting images are placed on the top of the layers. The viewer allows mouse-click real-time displacement zoom. At any time the user can modify the list of combined images, change viewing geometry, change colors, contrast, brightness and transparency of each raster layer.

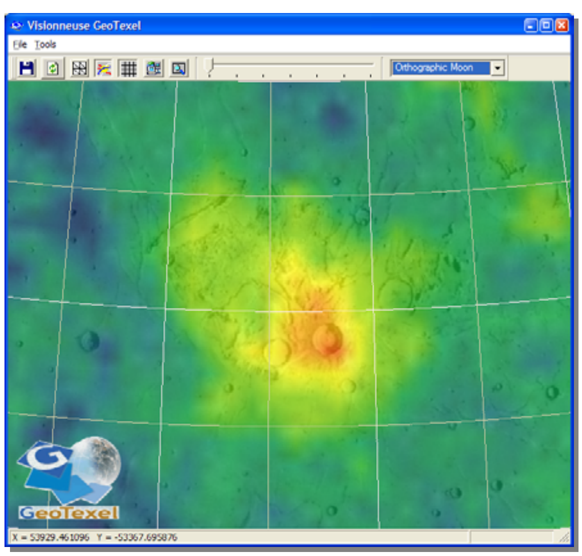

Figure 2: SPINS interactive viewer: Thorium data from Lunar Prospector [1] on top of the USGS airbrush map. Aritarchus crater on the Moon.

6/ Finally, when the user has found an area of interest, he/she can extract all layers, keep them assembled or disjoint, choose the re-sampling technique. XML metadata are also transferred.

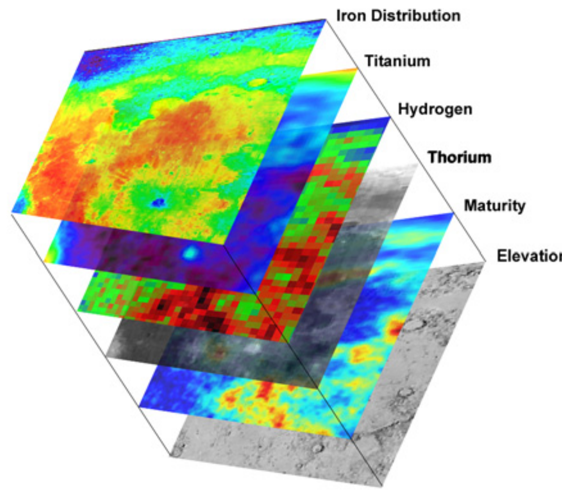

Figure 3: At Aristarchus on the Moon, extraction of a matrix, with original images resized to the same resolution and geometry: Topography from Clementine Lidar [2]; Iron, Titanium, Maturity maps from Clementine spectral reflectance [3]; Hydrogen from Neutron detector onboard Lunar Prospector [4]; Thorium from Gamma-ray detector onboard Lunar Prospector [1].

Status: A prototype of SPINS has been developed by the end of 2002. It demonstrates all this was feasible, using real data over Moon and Mars, originally acquired through the PDS. This development in performed under the initiative of CNES, in the context of a future Data Center for Planetary Surfaces.

The SPINS project is aiming at truly using and exploiting scientific observations through the Internet making virtual planet exploration accessible to every planetologists, like a natural follow-up to spacecraft exploration.

References: [1] Lawrence et al., *J. Geophys. Res.*, 105, 20307, 2000. [2] Smith et al., *J. Geophys. Res.*, 102, 1591, 1997. [3] Lucey et al., *Science*, 268, 1150, 1995. [4] Maurice et al., LPSC XXXIV, this issue.